WAR DEPARTMENT,

SURG. GENL'S OFFICE.

REPORT ON THE MAGNESIUM & ELECTRIC LIGHTS IN PHOTO-MICROGRAPHY.

BY

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WAR DEPARTMENT,

U.S. SURGEON GENERAL'S OFFICE,

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REPORT TO THE SURGEON GENERAL,

OF THE

UNITED STATES ARMY,

ON THE

MAGNESIUM AND ELECTRIC LIGHTS,

AS APPLIED TO

PHOTO-MICROGRAPHY.

By Brevet Lieutenant Colonel J. J. WOODWARD,

Assistant Surgeon, U. S. Army.

WASHINGTON, D. C., 1870.

Army Medical Museum,
Microscopical Section,
January 4, 1870.

BREVET MAJOR GENERAL J. K. BARNES,
Surgeon General, U. S. Army.

General: I have the honor to inform you that on the 25th of October last, I began to conduct in person a series of experiments, intended to devise means for escaping certain difficulties which had hitherto prevented the successful preparation of Photo-micrographs of specimens, selected from the valuable and daily increasing series of permanently mounted microscopic sections of normal and pathological tissues, which form so interesting a portion of the treasures of the Museum. In these experiments I used the sun as a source of illumination, and following the process which I have described in full elsewhere,* I had no difficulty in arranging a method, by the aid of which this class of objects could be photographed quite as successfully and readily as the diatoms and other test objects which had previously been so satisfactorily reproduced in this section of the Museum. I shall take occasion in the course of a few days to lay before you prints of some of the tissue-preparations thus reproduced. At present it is my desire to call your attention to certain important observations which I had the good fortune to make, while my experiments were in progress, and which it appears to me cannot fail to be of interest and service to all microscopists.

During the last week of October and the first two weeks of November, I relied wholly on the sun as the source of illumination for producing negatives. In this period, during which I had but two perfectly cloudless working days, and several fractional days, on which my work was continually interrupted by passing clouds, I had ample opportunity to convince myself that the uncertainty of the weather was a most serious hindrance to the preparation of successful photographs of microscopic objects, and I ceased to wonder that European microscopists, who are exposed to a climate even more variable than our own, have not yet succeeded in placing the art of Photo-micrography upon such a basis, as to make it a convenient and habitual auxiliary in all microscopical investigations. This desirable end I believe I have attained; but it has been by resorting to artificial lights and thus making the success of the process wholly independent of the weather.

On the 12th of November I commenced a series of experiments with artificial lights which were most fortunately crowned with success, both the Magnesium and the Electric lights proving adequate sources of illumination for the production of Photo-micrographs even with the highest powers.

For the production of the Electric light I used a Duboscq's lamp, set in motion by a battery of fifty small Groves' elements. I found that with this source of light, photographs could be successfully taken with

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* Circular No. 6, War Department, Surgeon General's Office, Nov. 1, 1865, page 148, *et. seq.* American Journal of Science and Arts, Vol. XLII, Sept., 1866.

any power with which pictures can be taken by sunlight; and I was delighted to find, as I had anticipated, that the very exaggeration of light and shadow which has prevented the Electric light from being generally adopted as a source of illumination in the preparation of photographs of the size of the object, or smaller, proved of immense advantage in the reproduction of the feeble microscopical images of highly magnified objects, and that the pictures were hence clearer and better defined than any photographs of similar objects I had hitherto seen produced by sunlight. I found also that the Electric light was so much more manageable than sunlight as a source of microscopic illumination, that I could readily arrange it to produce negatives with much shorter exposures than are indispensable with the sun.

The Magnesium light shared these qualities to a high degree, but I found that its best work was done when the object was not to be magnified more than a thousand diameters, and that there were certain limitations to its use on test objects which will be referred to in the sequel.

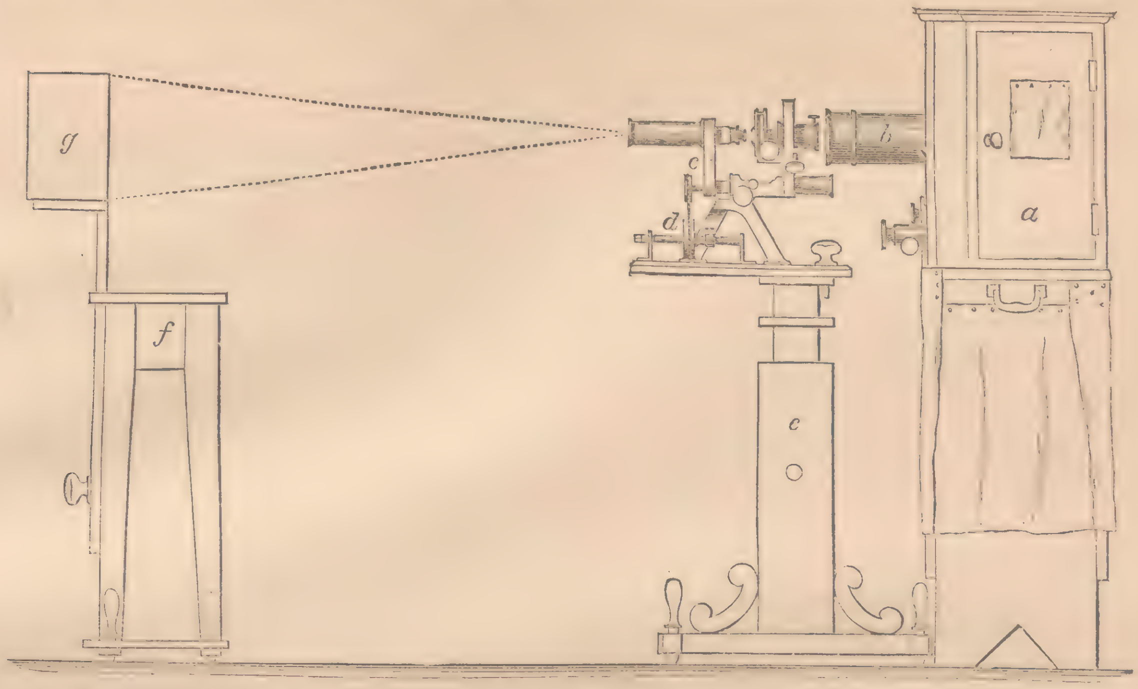
With one or the other of these artificial lights as a source of illumination, I have prepared a considerable number of negatives of interesting microscopical objects, of which a few are appended to this report by way of illustration, while the others will be laid before you in future reports on special subjects.

The Magnesium and Electric lights are mentioned as possible sources of illumination for the production of Photo-micrographs by Dr. Lionel Beale, in the 4th edition of his "How to Work with the Microscope," page 275. I am not aware, however, that any one has made successful negatives with high powers with either of these lights prior to the experiments here recorded. There are in the Museum a few photographs with low powers taken with the Magnesium light by Dr. C. F. Crehore, of Boston, Mass., who kindly presented them August 3, 1866. Negative No. 90, old Microscopical Series, Army Medical Museum, represents a few villi from the small intestine of a mouse, photographed by the Electric light with a 4-10th objective of Wales arranged to magnify 84 diameters. The Electric light was produced by forty Bunsen's cells, and as I had no Electric lamp at the time, I held the carbon points in two retort holders and managed as best I could, during the exposure, the uncertain light thus produced. I know of no other Photo-micrographs than the above to have been actually made by the Electric or the Magnesium lights; certainly if any have been, they have not been sufficiently successful for their authors to be willing to give them any degree of publicity. I have no hesitation therefore in claiming for the Museum and for myself the credit of having demonstrated the serviceable character of these lights as sources of illumination for the preparation of negatives with high powers, and of having devised a simple method which brings their use within the reach of every microscopist.

I propose now to sketch briefly the process by which negatives of microscopic objects can be conveniently produced with these artificial lights.

1. The Electric light is by far the best of all artificial lights for the production of Photo-micrographs, and when used, as I am now about to describe, it is both convenient and economical. I use a Grove's battery of fifty elements. The battery is placed just outside of the operating room in a closet from which the fumes escape through an earthen pipe into the main chimney of the building. This battery was furnished by Mr. William Ladd, Nos. 11 and 12, Beck street, Regent street, London, W. The rubber cups are 4¾ inches high, 3¼ wide and 2 thick. The platinums are 5½ inches by 2½, and weigh about 69 grains each. The zincs are bent on themselves so as to present a part of their surface on each side of the platinums, and weigh, when new, about a pound apiece. Mr. Ladd furnishes these batteries in trays of ten elements, at five pounds sterling per tray, and I find that a battery of five trays is sufficient for most purposes. Seven pounds and a half of strong commercial nitric acid, and three of sulphuric, diluted with ten times the quantity of water, is sufficient to charge this battery, which will then produce the light continuously for from three to four hours. The cost of running the battery for this time, including in the estimate the amount of zinc consumed, and the cost of amalgamating every third or fourth time of using, is very moderate. I make it a practice to have the battery washed out, the acids thrown away and the porous cups put to soak immediately after I have done the day's work, and all this is so simple that I have had no difficulty in instructing an orderly to do it, so that the management of the battery does not occupy any part of my time.

The Duboscq's lamp, the microscope and the plate holder are arranged in a dark room which enables me to dispense with the use of a camera. The general arrangement of the apparatus is shown in the cut.



The Electric lamp of Duboscq (*a*) is placed on a stool against the wall at one end of the room, and its light concentrated by a pair of condensing lenses (*b*) on the lower lens of the achromatic condenser of the microscope. The microscope (*c*) (a large Powell and Lealand's stand) is placed on a small table (*e*) which is so arranged that it can be lowered or elevated at pleasure and can be levelled by means of three levelling screws at its base. The plate holder (*g*), also arranged so that it can be raised or lowered at pleasure, is supported by a small table (*f*) which stands on three levelling screws. The floor of the apartment is quite level. The lenses employed for the microscope are those of Mr. William Wales of Fort Lee, New Jersey, specially constructed for bringing the actinic rays to a focus. For powers above the ⅛th, however, I have found that the achromatic objectives of Messrs. Powell and Lealand, of London, answer an excellent purpose, and indeed that their immersion 1-16th exceeds in defining powers any objective which has as yet come under my notice.

In taking photographs with this apparatus, I proceed as follows: The Electric lamp being set in motion, the table holding the microscope (which has previously been levelled), is raised or lowered and moved from side to side till the centre of the achromatic condenser is brought to the centre of the illuminating pencil proceeding from the lamp; the object is then placed on the stage and carefully adjusted. A cell of plate glass containing a saturated solution of the ammonio-sulphate of copper is fixed just below the achromatic condenser, and not only prevents the admission of non-actinic rays, but excludes the very great heat which accompanies the Electric light, and also moderates its effect upon the eye of the observer. The light thus produced is very agreeable to the eye, and I find myself able to work with it from four to five hours without fatigue. It has also the advantage that all the colors of the object examined disappear, and the preparation appears black on an azure field which resembles the sky on a clear day, so that the observer sees at a glance how the object will appear in the photograph (in which the same black lines or tints will be faithfully reproduced on a white field) and is thus enabled to arrange his achromatic condenser and other adjustments so as to produce the most satisfactory effect.

Every thing having been arranged at the microscope to the satisfaction of the observer, the eyepiece is taken out, and, the image allowed to fall on the ground glass of the plate holder, which has previously been placed at the distance necessary to give the magnifying power desired with the objective employed.

The operator adjusts the plate holder to the right height and sees that it is perpendicular to the optical axis of the microscope, which he readily does by observing that all parts of the field are equally in focus. He then takes out the ground glass and finishes the fine adjustment with a sheet of plate glass and a focussing glass, after which the sensitive plate is inserted, the exposure made and the operation is finished.

To enable the observer to focus the microscope while sitting at a distance from it at the sensitive plate, the following contrivance is employed. On the table which supports the microscope (*e*) two brass shoulders, each two inches high, are screwed. Through these runs an iron rod nine inches long, on which slips a brass pulley (*d*) which can be clamped at any point. A cord connects this pulley with the wheel of the fine adjustment of the microscope which is grooved for the purpose. It is evident that whenever this iron rod is turned, the pulley turning with it will move the fine adjustment of the microscope. To effect this, the iron rod terminates in a square extremity, so that a joint of an ordinary fishing rod, to which a brass ferrule, shaped like a watch key, has been rivetted, enables the operator to focus the microscope at any ordinary distance. When greater distances are required two joints of the rod may be used. The rod, being graduated into feet and inches, enables the operator to record the distance employed for each picture. When the focussing is completed, the rod is removed. I have found this simple and cheap arrangement superior in delicacy and convenience to any of the more costly arrangements, I have heretofore tried.

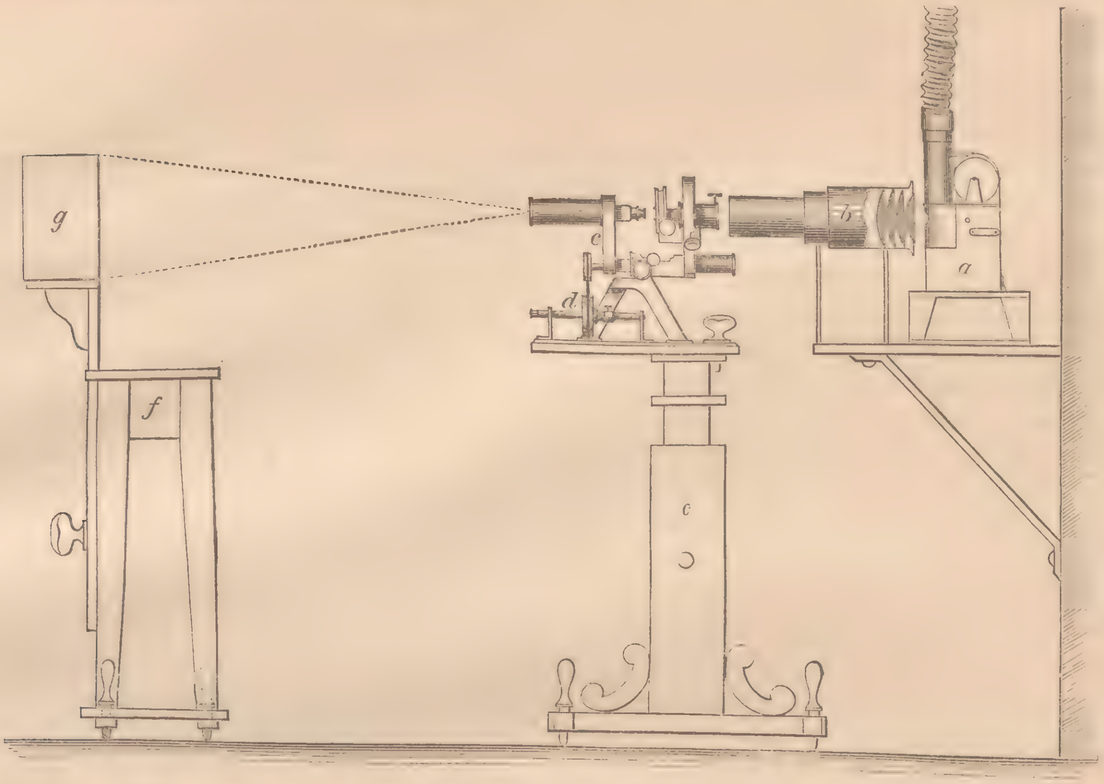
The chemical processes, employed in taking the negatives, do not differ in any respect from those used in ordinary photographic work, and I have found that by employing a practical photographer, allowing him to manage the dark room and confining my whole attention to the optical arrangements, I not only get many times more pictures in a day, but they are much better than can be produced by any one who attempts to do the photographic work, as well as manage the microscope himself.

I find myself thus enabled to sit down quietly of an evening, and during four hours work to produce from twelve to thirty negatives or more, in accordance with the difficulty of the subjects and my previous knowledge of them. Any microscopist who is willing to go to the moderate expense of battery and lamp, and to add two or three specially constructed objectives to his microscopical apparatus, can, by employing a photographer one or two evenings in the month, reproduce all the more interesting of his month's observations with a degree of economy and beauty not to be obtained by any other means, and if he follows the method I have above described, the character of his results will be conditioned by his skill as a microscopist rather than by any other circumstance. As to the time of exposure required for taking negatives with the Electric light, I find that for one thousand diameters about thirty seconds is necessary for that class of objects, (such as Angulatum, the Nobert's plate, &c.,) for which it is not necessary to employ a ground glass plate to prevent interference phenomena. In photographing the soft tissues and many other objects, it is necessary to insert a piece of ground glass below the achromatic condenser to escape the interference phenomena which else occur, precisely as must be done in photographing the same objects by sunlight. This increases the time of exposure to about three minutes for one thousand diameters. Other powers require proportional times.

2. The Magnesium light affords a beautiful source of illumination comparable to white cloud illumination of the best character, or to the light of the sun after it has passed through a sheet of ground glass. Without the use of ground glass, this light serves admirably for the production of photographs of the soft tissues with any power under a thousand diameters. The light being composed of a mixed pencil, with rays passing in all directions, there are no interference phenomena, but for the same reason, on the Nobert's plate and many test objects, the results are inferior to those produced by the sun or by the Electric light; with powers much higher than a thousand diameters, however, the time of exposure becomes inconveniently long.

The process employed by me in the production of negatives with the Magnesium light, is essentially the same as I have above described for the Electric light, simply the Magnesium lamp is substituted for the

Electric, and the condenser of an ordinary Oxy-calcium Magic Lantern is made to concentrate the light on the achromatic condenser of the microscope. The cut represents the arrangement. The Magnesium lamp (*a*)



stands on a shelf fastened against the wall. The condenser (*b*) concentrates the light on the lower lens of the achromatic condenser of the microscope, (*c*) which stands on a table (*e*) supported on three levelling screws. The image received on the plate holder. (*g*) which is supported on a table. (*f*) is photographed precisely as in the case of the Electric light as above described. The same focussing apparatus (*d*) is employed and the ammonio-sulphate cell should invariably be inserted, but the ground glass is never necessary. I find that it requires exposures of about three minutes to produce negatives of tissue-preparations with five hundred diameters. Other powers require proportionate exposures.

The Magnesium lamp used by me for this purpose was the two-ribbon lamp of the American Magnesium Company, (No. 2 Liberty Square, Boston, Mass.,) sold by that company for Magic Lantern purposes, price $50. The ribbon weighs about 52 centigrammes per metre, and is sold at $2.50 per ounce. Two ounces will, with care, answer for three or four hours constant work, and ought to produce from twelve to thirty negatives in accordance with the difficulties of the subjects to be represented. The fumes of Magnesia resulting from the combustion are carried into a chimney five feet long, made of a spiral wire covered with muslin, which terminates in a muslin bag in which the oxide condenses, while the draft goes on through the interstices of the muslin. The chimney and bag are furnished by the company for $2.50.

In commenting on the above processes it may be remarked that for the anatomist and physiological investigator, the Magnesium lamp affords a satisfactory and sufficient source of light for the photography of normal and pathological tissue-preparations. The same end can be equally well or even better attained with the Electric lamp, with which also the most difficult test objects can be satisfactorily reproduced. Where economy of apparatus is the object, the Magnesium lamp will be preferred by ordinary workers; but where much work is to be done, the high price of the Magnesium ribbon more than counterbalances the cheapness of the apparatus, and the Electric light becomes the most economical. For the information of any practical photographers who may be employed for work of this character, I may add the following remarks on the chemical process employed in the production of the negatives from which the appended

prints were made. An ammonium and potassium portrait collodion, rich in alcohol, was employed, developed with the ordinary solution of iron, and fixed with cyanide of potassium. Where it was necessary to intensify, the hydro-sulphuret of ammonium was resorted to.

In illustration of the character of these sources of illumination as compared with each other and with sunlight, I herewith append three prints from negatives, taken with a Wales' inch and a half, from the 6th square of a Möller's diatom type-plate, specially prepared for the Army Medical Museum by that skillful microscopist. The first, from Negative 79 (new series), was taken by sunlight, with 40 diameters; in the second, from Negative 123 (new series), the Magnesium light was used, and every thing else remaining the same, the distance was increased so as to give 48 diameters; in the third, Negative 158 (new series), the Electric lamp was employed, and every thing else still remaining unaltered, the distance was increased so as to give 66 diameters. It will be understood at once, that on account of the increase of distance, the second picture would have been slightly less sharp than the first, and the third than the second, had precisely the same source of light been employed; nevertheless, in spite of this disadvantage, to which they were purposely exposed, the Magnesium and Electric pictures are far superior to that taken by sunlight, and of the two the Electric is much the best. It is especially to be observed, that in the Electric picture the contrast obtained is so great that the objects appear clearly defined on an almost perfectly white ground, which is never the case with Photo-micrographs taken with the sun as a source of illumination.

As a further illustration of the capabilities of the Magnesium and Electric lights, I add a few photographs taken by each.

BY THE MAGNESIUM LIGHT.

Arachnoidiscus Ehrenbergii. Magnified 400 diameters, by Wales' 1/8th. Negative 114 (new series).

Small vein and capillaries, from the muscular coat of the urinary bladder of the frog. Magnified 400 diameters, by Wales' 1/8th. Negative 103 (new series). This Negative is taken from preparation No. 3378, Microscopical Series, in which the bladder was injected with a half per cent solution of nitrate of silver, and subsequently stained with carmine dissolved in borax. The epithelium was then brushed off with a camel's hair pencil, and the preparation transferred through absolute alcohol to canada balsam; the photograph reproduces every thing but the color.

BY THE ELECTRIC LIGHT.

Pleurostaurum Acutum. Magnified 340 diameters, by Wales' 1/8th. Negative 109 (new series.)

Triceratium Favus. Magnified 340 diameters, by Wales' 1/8th. Negative 110 (new series).

Navicula Spima. Magnified 840 diameters, by Powell and Lealand's immersion 1-16th. Negative 112 (new series).

Human red blood corpuscles. Magnified 1,000 diameters, by Powell and Lealand's immersion 1-16th. Negative 145 (new series).

Section of an epithelial cancer of the larynx. Magnified 400 diameters, by Wales' 1/8th. Negative 162 (new series). This Negative is taken from preparation No. 2277, Microscopical Section. The print shows the nuclei and cells of the growth with great distinctness.

Grammatophora Marina. Magnified 2,500 diameters, by Powell and Lealand's immersion 1-16th. Negative 151 (new series).

I have the honor to be, General,

Very respectfully,

Your obedient servant,

J. J. WOODWARD,

Assistant Surgeon and Brevet Lieutenant Colonel, U. S. A.,
In charge of the Record and Pension Division, and of the Medical, Microscopical and Comparative Anatomy Sections of the Army Medical Museum.

WAR DEPARTMENT,

Surgeon General's Office, Army Medical Museum.

The Sixth Square of a Möller's

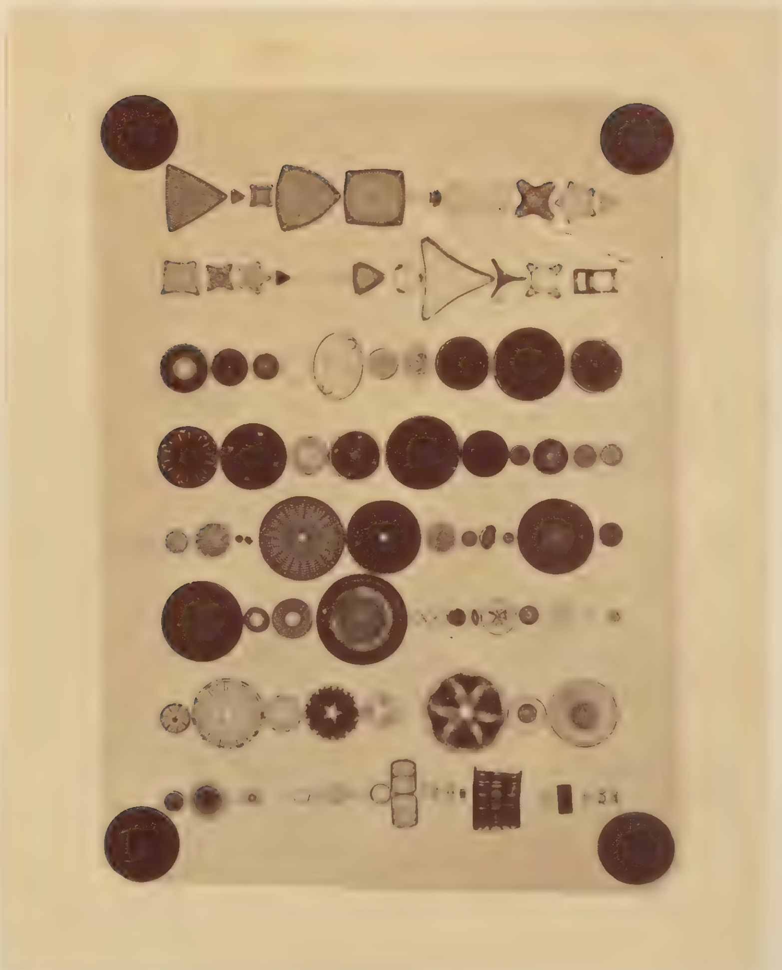
TYPE-PLATE OF THE DIATOMACEÆ.

Specially arranged for the Museum.

Magnified 40 diameters by Wales' inch and a half objective.
Photo-Micrographic Negative No. 79, New Series.
Taken by Sunlight.

By Brevet Lieutenant Colonel J. J. WOODWARD, Asst. Surg., U S. A.

BY ORDER OF THE SURGEON GENERAL.



WAR DEPARTMENT,

Surgeon General's Office, Army Medical Museum.

The Sixth Square of a Möller's

TYPE-PLATE OF THE DIATOMACEÆ.

Specially arranged for the Museum.

Magnified 48 diameters by Wales' inch and a half objective.
Photo-Micrographic Negative No. 123. New Series.
Taken by the Magnesium Light.

By Brevet Lieutenant Colonel J. J. WOODWARD, Asst. Surg., U. S. A.

BY ORDER OF THE SURGEON GENERAL.

WAR DEPARTMENT,

Surgeon General's Office, Army Medical Museum.

The Sixth Square of a Mötler's

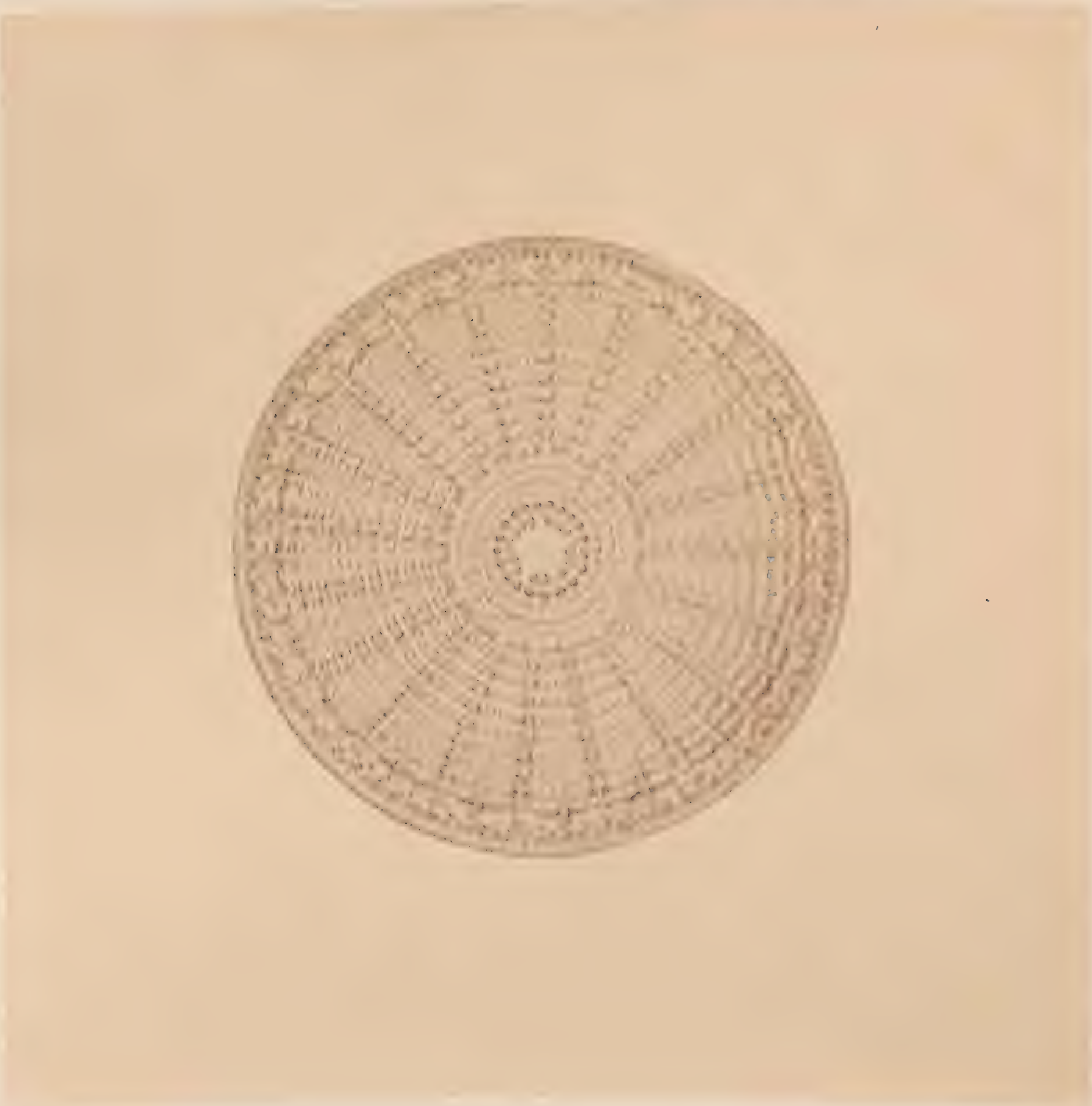
TYPE-PLATE OF THE DIATOMACEÆ.

Specially arranged for the Museum.

Magnified 66 diameters by Wales' inch and a half objective.
Photo-Micrographic Negative No. 157, New Series.
Taken by the Electric Light.

By Brevet Lieutenant Colonel J. J. WOODWARD, Asst. Surg., U. S. A.

BY ORDER OF THE SURGEON GENERAL.



WAR DEPARTMENT,

Surgeon General's Office, Army Medical Museum.

ARACHNOIDISCUS EHRENBERGII.

Magnified 400 diameters by Wales' one-eighth objective.
Photo-Micrographic Negative No. 114. New Series.
Taken by the Magnesium Light.

By Brevet Lieutenant Colonel J. J. WOODWARD, Asst. Surg., U. S. A.

By order of the Surgeon General.

WAR DEPARTMENT,

Surgeon General's Office, Army Medical Museum.

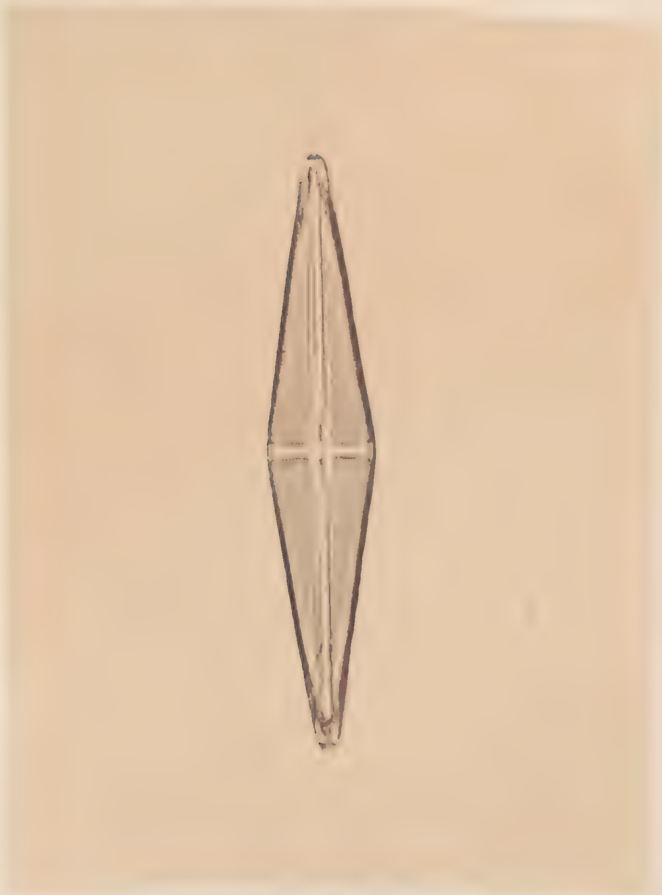
SMALL VEIN AND CAPILLARIES from the muscular coat of the Urinary bladder of the Frog.

The preparation copied, (No. 3378, Microscopical Series) had the bloodvessels injected with a half per cent. solution of nitrate of silver by which the boundaries of the epithelial cells were stained; the nuclei were subsequently tinged with carmine and the portion selected mounted in Canada balsam.

Magnified 400 diameters by Wales' one-eighth objective.
Photo-Micrographic Negative No. 103, New Series.
Taken by the Magnesium Light.

By Brevet Lieutenant Colonel J. J. WOODWARD, Asst. Surg., U. S. A.

BY ORDER OF THE SURGEON GENERAL.



WAR DEPARTMENT,

Surgeon General's Office, Army Medical Museum.

PLEUROSTAURUM ACUTUM.

Magnified 340 diameters by Wales' one-eighth objective.
Photo-Micrographic Negative No. 109, New Series.
Taken by the Electric Light.

By Brevet Lieutenant Colonel J. J. WOODWARD, Asst. Surg., U. S. A.

BY ORDER OF THE SURGEON GENERAL.

WAR DEPARTMENT,

Surgeon General's Office, Army Medical Museum.

TRICERATIUM FAVUS.

Magnified 340 diameters by Wales' one-eighth objective.
Photo-Micrographic Negative No. 110, New Series.
Taken by the Electric Light.

By Brevet Lieutenant Colonel J. J. WOODWARD, Asst. Surg., U. S. A.

BY ORDER OF THE SURGEON GENERAL.

WAR DEPARTMENT,

Surgeon General's Office, Army Medical Museum.

NAVICULA SPIMA.

Magnified 840 diameters by Powell and Lealand's immersion one-sixteenth objective.
Photo-Micrographic Negative No. 112, New Series.
Taken by the Electric Light.

By Brevet Lieutenant Colonel J. J. WOODWARD, Asst. Surg., U. S. A.

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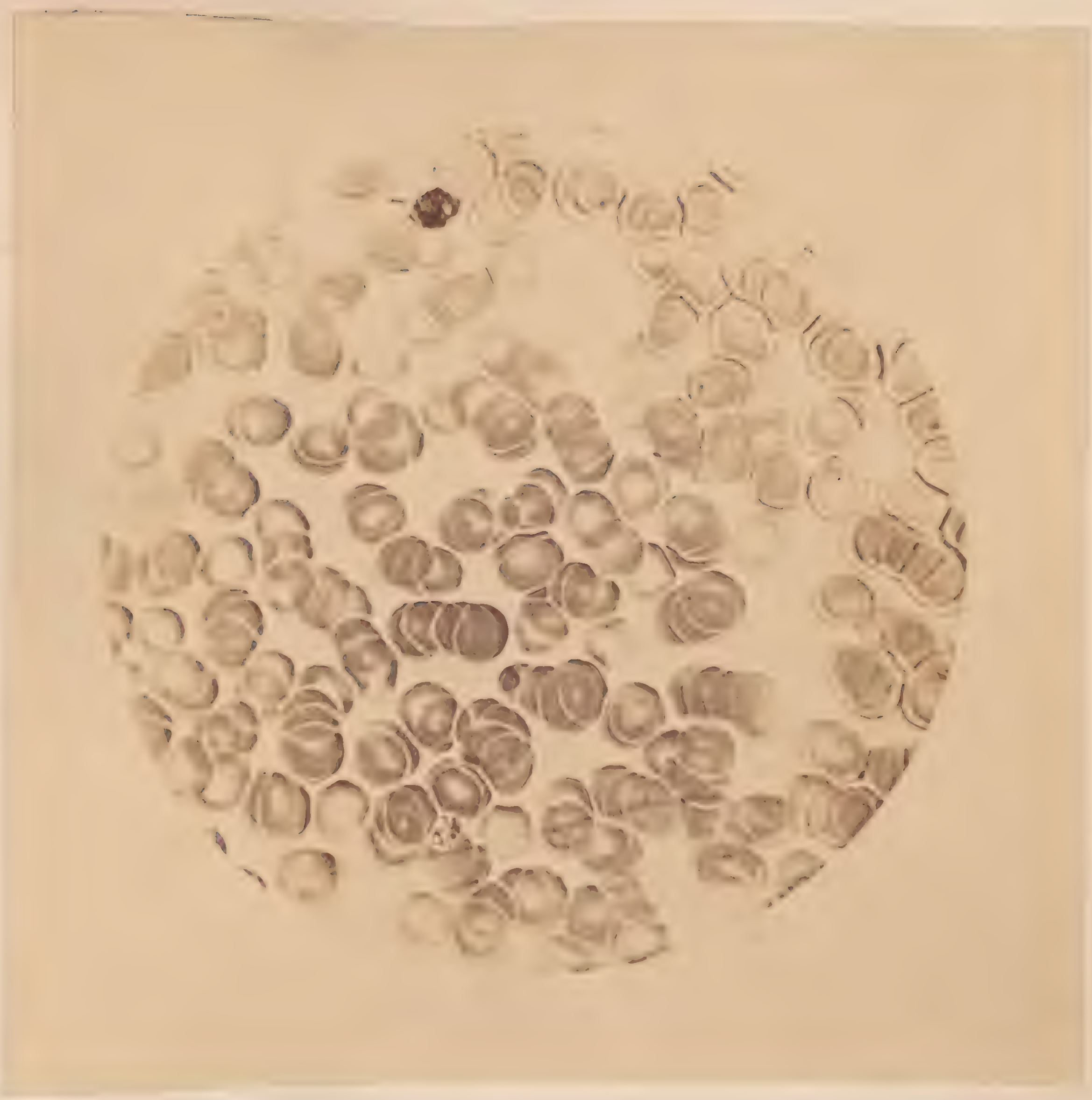


WAR DEPARTMENT,

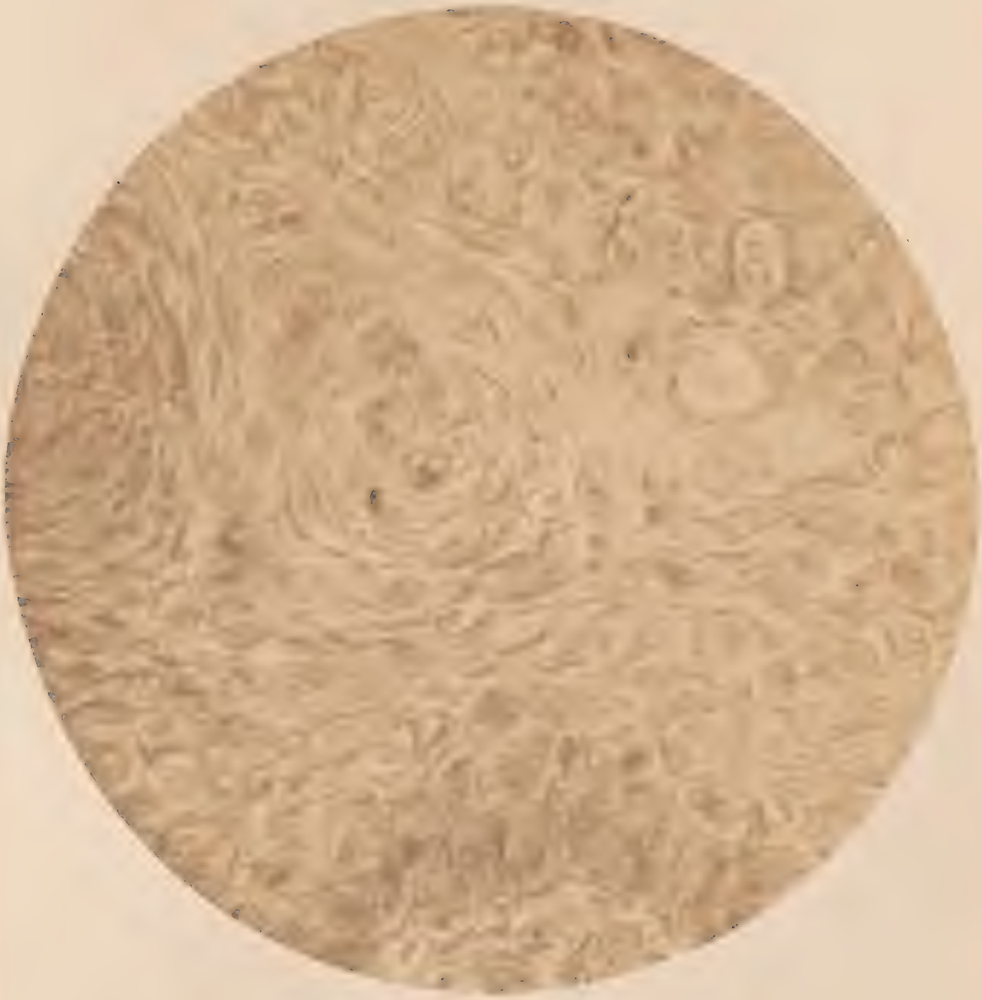
Surgeon General's Office, Army Medical Museum.

HUMAN RED BLOOD CORPUSCLES.

Magnified 1,000 diameters by Powell and Lealand's immersion one-sixteenth objective.
Photo-Micrographic Negative No. 145, New Series.
Taken by the Electric Light.

Brevet Lieutenant Colonel J. J. WOODWARD, Asst. Surg., U. S. A.

By order of the Surgeon General.



WAR DEPARTMENT,

Surgeon General's Office, Army Medical Museum.

Section of an EPITHELIAL CANCER of the LARYNX.

From preparation No. 2277, Microscopical Section.

Magnified 400 diameters by Wales' one-eighth objective.
Photo-Micrographic Negative No. 162, New Series.
Taken by the Electric Light.

By Brevet Lieutenant Colonel J. J. WOODWARD, Asst. Surg., U. S. A.

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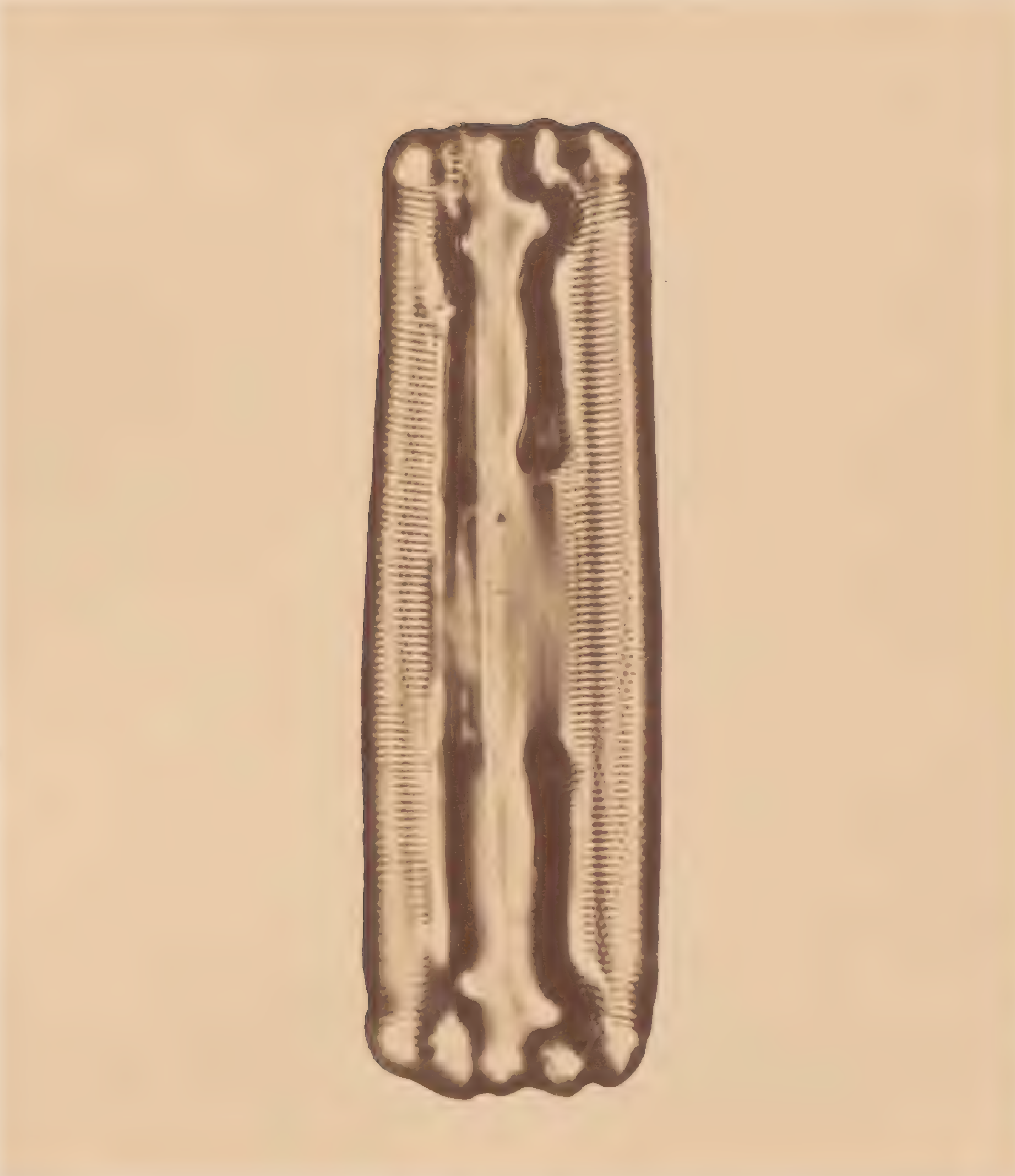

WAR DEPARTMENT,

Surgeon General's Office, Army Medical Museum.

GRAMMATOPHORA MARINA.

Magnified 2,500 diameters by Powell and Lealand's immersion one-sixteenth objective.
Photo-Micrographic Negative No. 151, New Series.
Taken by the Electric Light.

By Brevet Lieutenant Colonel J. J. WOODWARD, Asst. Surg., U. S. A.

BY ORDER OF THE SURGEON GENERAL.